

CONCLUSIONS.

1. The Naturally Infected Dog strain differs slightly from the other strains of the trypanosome causing disease in man in Nyasaland, in that there are fewer of the posterior-nucleated, blunt-ended forms which are sometimes so much in evidence in the ordinary strains.

2. Taking into consideration the fact that this strain was only found in three chronically infected dogs, it is concluded that it is an aberrant strain of the widely spread species *T. brucei vel rhodesiense*, the trypanosome causing disease in man in Nyasaland.

DESCRIPTION OF PLATES.

Trypanosome of Naturally Infected Dog.

Plate 9.—Short and Stumpy, Non-flagellated Forms.

Plate 10.—Intermediate Forms.

Plate 11.—Long and Slender Forms.

× 2000.

*The Trypanosome causing Disease in Man in Nyasaland.
The Naturally Infected Dog Strain. Part II.—Susceptibility
of Animals.*

By Surgeon-General Sir DAVID BRUCE, C.B., F.R.S., A.M.S.; Major A. E. HAMERTON, D.S.O., and Captain D. P. WATSON, R.A.M.C.; and Lady BRUCE, R.R.C. (Scientific Commission of the Royal Society, Nyasaland, 1912–14.)

(Received April 16,—Read June 25, 1914.)

INTRODUCTION.

In a previous paper* the morphology of the three strains of this trypanosome, from three naturally infected dogs, was described, and the strains compared with each other and with the Human strain.

This paper describes the action on various animals of the three strains and tabulates a comparison with the Human strain.

The first strain—Dog 48—was studied in a fairly large number of animals, but the second and third in few, as both were accidentally lost.

* ‘Roy. Soc. Proc.,’ B, vol. 88, p. 111 (1914).

SUSCEPTIBILITY OF ANIMALS TO THE NATURALLY INFECTED DOG STRAIN.

I. Strain I, Dog 48.

Table I.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Cattle.					
1912.					
Mar. 6...	314	From Dog 210	—	—	Never showed trypanosomes.
" 6...	315	" 210	—	—	" " "
April 13...	314	From Rat 311	12	—	Still alive after 335 days.
" 13...	315	" 311	—	—	Never showed trypanosomes.
Goat.					
Mar. 6...	275	From Dog 210	—	—	Never showed trypanosomes.
" 6...	277	" 210	—	—	" " "
April 5...	275	From Rat 312	24	—	Accidentally killed.
" 5...	277	" 312	—	—	Never showed trypanosomes.
" 20...	427	" 392	10	—	Still alive after 277 days.
" 20...	432	" 392	26	—	" " "
1913.					
Mar. 21...	2008	" 1991	—	—	Never showed trypanosomes.
" 21...	2009	" 1991	27	—	Still alive after 251 days.
" 21...	2010	" 1991	—	—	Never showed trypanosomes.
" 21...	2011	" 1991	17	—	Died of pneumonia.
" 21...	2012	" 1991	—	—	Never showed trypanosomes.
" 21...	2013	" 1991	—	—	" " "
" 21...	2014	" 1991	24	—	Still alive after 251 days.
" 21...	2015	" 1991	17	—	" " "
" 21...	2016	" 1991	—	—	Never showed trypanosomes.
" 21...	2017	" 1991	—	—	" " "
Sheep.					
1912.					
April 20...	456	From Rat 392	5	—	Still alive after 340 days.
" 20...	457	" 392	10	64	Died of Strain I.
Antelope.					
1913.					
May 21...	2059	From Rat 2024	13	—	Still alive after 250 days.
Monkey.					
1912.					
Mar. 6...	318	From Dog 210	—	—	Never showed trypanosomes.
April 5...	318	From Rat 312	—	—	" " "
" 20...	50	From Dog 317	—	—	" " "
" 20...	453	From Rat 392	—	—	" " "
Oct. 29...	1533	" 1491	—	—	" " "
" 29...	1534	" 1491	6	—	Still alive after 148 days.
Nov. 22...	1629	From Monkey 1534 ...	—	—	Never showed trypanosomes.
" 27...	1630	" 1534 ...	10	—	Still alive after 124 days.

* Duration includes the days of incubation : it dates from the day of inoculation.

Table I—*continued.*

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Monkey— <i>continued.</i>					
1913.					
Jan. 22...	1792	From Rat 1741	5	—	Still alive after 186 days.
" 22...	1793	" 1741	5	—	" " "
" 22...	1794	" 1741	—	—	Never showed trypanosomes.
" 22...	1798	From Monkey 1630 ...	—	—	" " "
Feb. 28...	1794	From Rat 1945	—	—	" " "
" 28...	1798	" 1945	—	—	" " "
May 22...	1794	From Monkey 2131 ...	—	—	" " "
" 22...	1798	" 2131 ...	—	—	" " "
June 11...	1794	" 2184 ...	—	—	" " "
" 11...	1798	" 2184 ...	—	—	" " "
Dog.					
1912.					
Feb. 17...	210	From Rat 67	8	25	Died of Strain I.
Mar. 6...	317	From Dog 210	—	—	Never showed trypanosomes.
" 13...	331	From Rat 67	—	—	" " "
April 6...	317	" 312	12	16	Died of Strain I.
" 13...	331	" 311	12	46	" " "
" 20...	458	From Dog 317	—	—	Never showed trypanosomes.
" 20...	459	" 317	19	—	Still alive after 224 days.
Sept. 6...	1253	From Rat 1218	6	—	" " 120 "
Oct. 29...	1525	" 1491	13	30	Died of Strain I.
" 29...	1526	" 1491	23	53	" " "
" 29...	1527	" 1491	—	—	Never showed trypanosomes.
" 29...	1528	" 1491	13	21	Died of Strain I.
" 29...	1529	" 1491	13	47	" " "
" 29...	1530	" 1491	16	—	Still alive after 148 days.
1913.					
Jan. 22...	1795	From Rat 1741	5	29	Died of Strain I.
" 22...	1796	" 1741	8	35	" " "
" 22...	1797	" 1741	22	—	Still alive after 131 days.
April 14...	2054	Laboratory-bred flies...	7	30	Died of Strain I.
May 29...	2197	From Dog 2054	11	16	" " "
" 29...	2198	" 2054	4	13	" " "
Dec. 30...	2483	From Rat 2471	14	34	" " "
1914.					
Jan. 26...	2498	From Dog 2483	4	11	Died of Strain I.
Average.....			11.6	29.0	
Rabbit.					
1912.					
Mar. 30...	389	From Rat 67	9	256	Died of Strain I.
" 30...	390	" 67	17	109	" " "
Average.....			13.0	182.5	
Guinea-pig.					
Mar. 6...	313	From Dog 210	—	—	Never showed trypanosomes.
April 5...	313	From Rat 312	—	—	" " "
" 20...	460	" 392	—	—	" " "
" 20...	461	" 392	—	—	" " "
Oct. 29...	1531	" 1491	—	—	" " "
" 29...	1532	" 1491	—	—	" " "
Nov. 13...	1531	" 1492	—	—	" " "
" 13...	1532	" 1492	—	—	" " "

* Duration includes the days of incubation; it dates from day of inoculation.

Table I—continued.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Guinea-pig—continued.					
1913.					
Jan. 17...	1775	" 1734	—	—	Never showed trypanosomes.
June 17...	2228	" 2215	—	—	" "
" 17...	2229	" 2215	6	—	Still alive after 246 days.
July 22...	2307	" 2285	—	—	Never showed trypanosomes.
" 22...	2308	" 2285	—	—	" "
" 31...	2307	" 2285	—	—	" "
" 31...	2308	" 2285	—	—	" "
Rat.					
1912.					
Mar. 26...	311	From Rat 67	13	18	Died of Strain I.
" 26...	312	" 67	9	60	" "
" 30...	391	" 67	9	21	" "
" 30...	392	" 67	9	21	" "
April 5...	407	" 312	10	54	" "
" 20...	462	" 407	10	25	" "
May 25...	585	" 407	5	28	" "
June 4...	670	" 585	6	27	" "
July 2...	786	" 670	6	45	" "
Aug. 2...	1020	" 786	6	30	" "
" 30...	1218	" 1020	3	94	" "
Oct. 19...	1492	" 1218	9	54	" "
Dec. 12...	1687	" 1492	4	16	" "
" 28...	1719	" 1687	9	32	" "
1913.					
Jan. 3...	1734	" 1570	9	36	" "
" 3...	1735	" 1570	6	39	" "
" 7...	1741	" 1719	4	15	" "
" 9...	1749	" 1719	4	18	" "
" 27...	1814	" 1749	7	16	" "
Feb. 10...	1855	" 1814	3	20	" "
" 22...	1945	" 1855	5	17	" "
Mar. 7...	1985	" 1945	6	20	" "
" 25...	2022	" 1985	6	16	" "
" 25...	2023	" 1985	6	18	" "
" 25...	2024	" 1985	6	19	" "
April 10...	2070	" 2023	4	12	" "
" 22...	2105	" 2070	6	20	" "
May 7...	2124	" 2105	3	8	" "
" 13...	2134	From Dog 2054	2	12	" "
" 25...	2183	From Rat 2133	3	7	" "
" 15...	2168	" 2124	7	17	" "
" 13...	2133	From Dog 2054	6	10	" "
June 10...	2214	" 2197	3	10	" "
" 18...	2230	From Rat 2214	8	10	" "
Aug. 13...	2389	" 2280	8	48	" "
Sept. 6...	2409	" 2389	5	49	" "
" 16...	2413	" 2409	6	70	" "
Oct. 23...	2425	" 2413	5	64	" "
Nov. 12...	2432	" 2425	6	38	" "
Dec. 20...	2471	" 2432	6	22	" "
1914.					
Jan. 16...	2484	" 2471	7	16	" "
Average.....			6.2	28.6	

* Duration includes the days of incubation ; it dates from the day of inoculation.

II. *Strain II, Dog 690.*

Table II.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Monkey.					
1913. Sept. 13...	1314	From Dog 690	—	—	Never showed trypanosomes.
„ 13...	1315	„ 690	—	—	„ „
Dog.					
1912. June 17...	690	Naturally infected	?	—	Recovered.
Guinea-pig.					
1913. Sept. 13...	1316	From Dog 690	—	—	Never showed trypanosomes.
„ 13...	1317	„ 690	—	—	„ „
Rat.					
1912. July 18...	911	From Dog 690	7	30	Died of Strain II.

* Duration includes the days of incubation ; it dates from the day of inoculation.

III. *Strain III, Dog 2033.*

Table III.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Goat.					
1913. May 21...	2174	From Rat 2089	12	71	Cause of death uncertain.
„ 21...	2175	„ 2089	—	—	Never showed trypanosomes.
„ 21...	2176	„ 2089	—	—	„ „
„ 21...	2177	„ 2089	—	—	„ „
„ 21...	2178	„ 2089	12	—	Died of pneumonia.
Monkey.					
May 14...	2161	From Rat 2091	—	—	Never showed trypanosomes.
„ 14...	2162	„ 2091	8	—	Recovered.
„ 14...	2163	„ 2091	—	—	Never showed trypanosomes.
„ 14...	2164	„ 2091	—	—	„ „
„ 14...	2165	„ 2091	12	—	Recovered.
June 14...	2161	From Dog 2157	—	—	Never showed trypanosomes.
„ 14...	2164	„ 2157	—	—	„ „

* Duration includes the days of incubation ; it dates from day of inoculation.

Table III—continued.

Date.	No. of expt.	Source of virus.	Period of incubation, in days.	Duration of disease, in days.*	Remarks.
Dog.					
Mar. 28...	2033	Naturally infected.....	?	?	Died April 1.
May 14...	2156	From Rat 2091	15	40	Died of Strain III.
" 14...	2157	" 2091	8	33	" "
" 14...	2158	" 2091	8	26	" "
" 14...	2159	" 2091	15	93	" "
" 14...	2160	" 2091	15	102	" "
Average.....			12·2	58·8	
Guinea-pig.					
Mar. 28...	2039	From Dog 2033	—	—	Never showed trypanosomes.
" 28...	2040	" 2033	—	—	" "
May 21...	2180	From Rat 2089	22	—	Recovered.
" 21...	2181	" 2089	—	—	Never showed trypanosomes.
Rat.					
Mar. 28...	2037	From Dog 2033	13	73	Died of Strain III.
Apr. 16...	2089	From Rat 2037	5	15	" "
" 16...	2090	" 2037	5	87	" "
" 16...	2091	" 2037	5	28	" "
May 14...	2167	" 2091	8	57	" "
Oct. 23...	2426	From Guinea-pig 2180	11	19	" "
Average.....			7·8	46·5	

* Duration includes the days of incubation; it dates from the day of inoculation.

Disease set up in various Animals by the Trypanosome causing Disease in Man in Nyasaland. The Naturally Infected Dog Strain.

Ox.—This trypanosome does not appear to be virulent to the ox. Four experiments were made. The trypanosomes appeared in the blood of one of the oxen, and it was returned as "Recovered" after being under observation for 335 days. The parasites were only seen on three occasions in this ox, and then only in scanty numbers.

Goat.—The trypanosome also has little effect on goats. Twenty-one were inoculated. Of these 12 proved refractory; five showed the trypanosomes in their blood on one or two occasions in very scanty numbers, and were returned as "Recovered" after being under observation for nearly a year; four died, one from the result of an accident, two from pneumonia, and the remaining one only once showed the trypanosomes, and as no *post-mortem* examination was made it is impossible to say what was the cause of death. It may therefore be said that not a single goat of the 21 died of the disease.

Sheep.—Two sheep were inoculated. One recovered; the other died after 64 days, probably of the disease.

Monkey.—This trypanosome has little or no effect on monkeys. Twenty-seven were used as experimental animals. Twenty-one proved refractory; the remaining six were returned as "Recovered" after being under observation for several months.

Dog.—This strain has become, after several passages, virulent to dogs. Twenty-eight were used for experiment. Nineteen died, on an average, in 36·8 days (11 to 102); four never showed trypanosomes in their blood; and five recovered. The *post-mortem* appearances are the same as those found in Nagana: enlargement of the spleen, gelatinous œdema about the vessels at the base of heart, petechiæ of mucous membranes, and corneal opacity.

Rabbit.—Only two were inoculated. Both died, one after 109 days, the other after 256 days. Both showed corneal opacity and presented the same symptoms as those described in Nagana rabbits, but in a much milder degree.

Guinea-pigs.—The guinea-pig, like the monkey, is almost refractory to this strain. Twenty-one animals were inoculated. Nineteen of these proved refractory, and the remaining two only showed trypanosomes on one occasion and appear to have recovered. Rats inoculated with their blood remain unaffected.

White Rat.—This strain is virulent to rats. Forty-eight were inoculated, and all died, on an average, in 30·8 days (7 to 94), with enormous enlargement of spleen, and the blood swarming with trypanosomes.

COMPARISON OF THE THREE STRAINS OF THE TRYPANOSOME OF THE NATURALLY INFECTED DOG STRAIN IN REGARD TO THEIR VIRULENCE TOWARDS VARIOUS ANIMALS.

Table IV.—The Average Duration, in Days, of the Disease in various Animals of the three Strains. The letter R means that the animal is refractory.

Strain.	Ox.	Goat.	Sheep.	Monkey.	Dog.	Rabbit.	Guinea-pig.	White rat.
I	R.	R.	64	R.	29	182	R.	29
II	—	—	—	R.	—	—	R.	30
III	—	R.	—	R.	59	—	R.	46

Table V.—The Average Duration, in Days, of the Disease in various Animals of the three Strains combined. The letter R stands for “refractory.”

	Ox.	Goat.	Sheep.	Monkey.	Dog.	Rabbit.	Guinea-pig.	White rat.
Average duration, in days	R.	R.	64	R.	37	182	R.	31
Number of animals employed	4	21	2	27	19	2	21	48

Table VI.—The Percentages of Recoveries in various Animals infected with the Naturally Infected Dog Strain. Three strains combined.

	Ox.	Goat.	Sheep.	Monkey.	Dog.	Rabbit.	Guinea-pig.	White rat.
Percentages	100	100	50	100	21	0	100	0
Number of animals employed	1	7	2	6	24	2	2	48

From Table VI it will be seen that the Naturally Infected Dog strain is not fatal to oxen, goats, monkeys, or guinea-pigs, whereas it killed 79 per cent. of the dogs and 100 per cent. of the white rats.

COMPARISON OF THE TRYPANOSOME OF THE NATURALLY INFECTED DOG STRAIN WITH THE TRYPANOSOME CAUSING DISEASE IN MAN IN NYASALAND (TRYPANOSOMA BRUCEI VEL RHODESIENSE).

Table VII.—The Average Duration of Life, in Days, of various Animals infected with the Naturally Infected Dog Strain and the Human Strain. The letter R stands for “refractory.”

Strain.	Ox.	Goat.	Monkey.	Dog.	Rabbit.	Guinea-pig.	White rat.
Naturally infected dog	R.	R.	R.	37	182	R.	31
Human	134	42	26	34	28	67	30

It is curious that this strain, although evidently harmless to oxen, goats, monkeys, and guinea-pigs, is quite as virulent as the Human strain to dogs and rats.

Table VIII.—The Percentages of Recoveries in various Animals infected with the Naturally Infected Dog Strain and the Human Strain.

Strain.	Ox.	Goat.	Monkey.	Dog.	Rabbit.	Guinea-pig.	White rat.
Naturally infected dog	100	100	100	21	0	100	0
Human	80	0	0	0	0	0	0

This shows the great difference in regard to action on animals which exists between the Naturally Infected Dog strain and the Human strain,* and if similar tables referring to other strains—for example, the Zululand 1913 Strain†—be compared, the same difference is found. It might be said that this alone is sufficient to make it rank as another species, and, as already mentioned, if this strain had been found among the wild game and wild *Glossina morsitans* in Nyasaland, this would have been justified. It was, however, only found in three chronically infected dogs, and so it is thought best with our present knowledge to include it among the strains of *Trypanosoma brucei vel rhodesiense*.

If in the future it should be decided to give it specific rank the name *T. anceps* is suggested. This name seems appropriate on account of the uncertainty which exists as to the classification of this trypanosome.

CONCLUSIONS.

1. The Naturally Infected Dog strain is fatal to dogs, rabbits, and white rats, but oxen, goats, monkeys, and guinea-pigs appear to be refractory.

2. The Commission is of opinion that this is an aberrant or exceptional variety or strain of the trypanosome causing disease in man in Nyasaland—*T. brucei vel rhodesiense*.

* 'Roy. Soc. Proc.,' B, vol. 87, p. 35 (1913).

† *Ibid.*, B, vol. 87, p. 493 (1914).